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SPECIFICATION FOR PHOTOMETRIC INTEGRATORS

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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SPECIFICATION FOR PHOTOMETRIC INTEGRATORS

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SPECIFICATION FOR PHOTOMETRIC INTEGRATORS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 21 June 1963, after the draft finalized by the Electric Lamps and Accessories Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard covers photometric integrators suitable for the measurement of all normal light sources, such as tungsten filament electric lamps, tubular fluorescent and other gaseous discharge lamps. Formulæ for suitable paints for the internal surface of an integrator have also been included in Appendix A.

0.3 In this standard only a perfect integrator, namely, spherical type has been recognised. It may, however, sometimes be convenient and necessary to use an integrator with interior of a shape other than spherical. A cube may be used for comparison of lamps not differing too much in shape or light distribution. For tubular lamps, a rectangular box of square section or a cylinderical box with hemispherical ends may be used. Provided that such non-spherical integrators are large enough and that their other known limitations are respected particularly by the use of strictly substitutional methods of calibrations, and that in appropriate cases the provisions of this standard in respect of internal surface coating and selectivity or colour of integrator are observed, the performance may be held within the limits specified in this standard.

0.4 While preparing this standard considerable assistance has been derived from the following:

B. S. 354 : 1961 RECOMMENDATIONS FOR PHOTOMETRIC INTEGRATORS. British Standards Institution.

WALSH, J.W.T. Photometry, 3rd ed. London. Constable, 1958.

0.5 This standard is one of a series .of Indian Standards relating to lamps and lamp accessories. Other standards so far published in this series are:

IS : 418 - 1963 SPECIFICATION FOR TUNGSTEN FILAMENT GENERAL SERVICE ELECTRIC LAMPS (*Second Revision*)

IS : 897 - 1957 SPECIFICATION FOR TUNGSTEN FILAMENT ELECTRIC LAMPS FOR RAILWAY ROLLING STOCK

IS : 1534 (PART I) - 1960 SPECIFICATION FOR BALLASTS FOR FLUORESCENT LAMPS : PART I FOR SWITCH START CIRCUITS

IS : 1569 - 1963 SPECIFICATION FOR CAPACITORS FOR ELECTRIC DISCHARGE LAMPS (FLUORESCENT AND MERCURY VAPOUR)

IS : 1606 - 1960 SCHEDULE FOR AUTOMOBILE LAMPS

IS : 1901 - 1961 SPECIFICATION FOR VISUAL INDICATOR LAMPS

IS : 2183 - 1963 SCHEDULE FOR HIGH PRESSURE MERCURY VAPOUR LAMPS

IS : 2215 - 1963 SPECIFICATION FOR STARTERS FOR FLUORESCENT LAMPS (*Revised*)

IS : 2261 - 1963 SPECIFICATION FOR LAMPS FOR FLASHLIGHTS

IS : 2262 - 1963 SPECIFICATION FOR TRANSFORMERS FOR HIGH VOLTAGE LUMINOUS DISCHARGE TUBES

0.6 Wherever a reference to any Indian Standard appears in this specification, it shall be taken as a reference to the latest version of the standard.

0.7 Metric system has been adopted in India and all quantities and dimensions appearing in this standard have been given in this system.

0.8 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2 - 1960 Rules for Rounding Off Numerical Values (*Revised*). The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard covers the constructional and related details of photometric integrators suitable for the measurement of lumen output of all normal electric light sources, such as tungsten filament electric lamps, tubular fluorescent lamps and other gaseous discharge lamps.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Photometer — An instrument used for measuring photometric quantities.

2.2 Photometric Integrator — An instrument which enables luminous flux being emitted by a source to be determined by a single measurement.

2.3 Absorption Factor (of a Body) — Ratio of the luminous flux absorbed by the body to the flux it receives.

2.4 Reflection Factor — Ratio of the luminous flux reflected by a body (with or without diffusion) to the flux it receives. In mixed reflection, the (total) reflection factor is the sum of the components, the direct reflection factor (ρ_r) and the diffused reflection factor (ρ_d).

2.5 Secondary Standard Lamp — A constant and reproducible light source, the luminous intensity (or the luminous flux or the luminance) of which has been determined directly or indirectly by comparison with the primary standard.

2.6 Working Standard Lamp — A light source in regular use which is calibrated from time to time by reference to secondary standard source.

3. ACCURACY

3.1 The requirements specified in this standard are intended to ensure that the total uncorrected photometric error due to the integrator system itself will not exceed ± 2 percent for the intercomparison of the various types of tungsten filament lamp, and also for the intercomparison of other types of lamps by proper substitutional procedures.

NOTE — This figure for performance, of course, takes no account of any additional uncertainty which may, in some cases, arise from unsteady behaviour of the light source or sources, while it is open to the user to assess the integrator errors in any particular case and to improve the accuracy by applying the corresponding corrections.

4. SHAPE AND SIZE OF THE INTEGRATOR

4.1 Shape of Integrator — The interior of the integrator shall be spherical (a perfect integrator).

4.2 Designation of Size — The size of spherical integrator shall be designated by the internal diameter of the sphere.

4.3 Size of Integrator

4.3.1 For tungsten filament electric lamps, the size of the integrator should be at least six times the overall length of the lamp, exclusive of the cap.

4.3.2 For tubular fluorescent and other tubular lamps, the size of the integrator should be at least one and a half times the length of the lamp.

4.3.3 When measurements of luminous flux are required to be made to the highest accuracy, larger integrators of spherical form may be necessary.

5. CONSTRUCTION

5.1 Windows — To facilitate photometric measurements, the integrators shall be provided with a translucent window of circular shape with its edges and frame not more than one millimetre above or below the general internal surface of the integrator. The diameter of the circular window should be not more than one-tenth of the size of the integrator.

5.1.1 The window material should be such that, for a given value of incident illumination, the luminance by transmission should be, as far as possible, independent of the angle of incidence of the light. It should also have a neutral spectral transmission characteristic and be non-fluorescent.

5.2 Internal Surface Coating — The coating of the internal surface of the integrator should be matt, durable and non-fluorescent. It should not deteriorate to an extent greater than that specified in **5.3**, and its reflection factor for white light should be between 0·75 and 0·85.

NOTE — Suitable method for measuring the reflection factor is under consideration.

5.2.1 Recommendations regarding paints which have been found satisfactory are given in Appendix A, together with details of methods of preparation and use.

5.3 Selectivity or Colour of Integrator — The recommendations specified in **5.1** and **5.2** regarding the spectral properties of the window and the coating are directed to ensure that the spectral quality of the light emerging from the window should differ as little as possible from that of the direct light from the source, and particularly that such modification as inevitably remains should be equivalent to the action of a filter whose spectral transmission curve is of a simple, smooth type. When a physical photometer is used in conjunction with the integrator, it is usually easy to compensate for this residual selectivity of the integrator by a suitable adjustment of the overall spectral response of the photometric equipment. If, however, the compensation must be external to the photometer, as may be the case for visual methods of photometry, a filter of suitable thickness, whose spectral transmission is complementary to that of the integrator, should be placed over the window or observing aperture. Glass filters of the kind specifically designed for colour-temperature conversion will often be found suitable. The exactness of the compensation obtained by this means may be checked spectro-photometrically if suitable apparatus is available.

5.3.1 Alternatively, the following visual method may be used:

Two gas-filled tungsten filament lamps of the same type are adjusted in voltages until they give light of the same colour at approximately rated voltage. One lamp is then placed inside the integrator and its voltage readjusted until the light emitted from the window or observing aperture of the integrator matches that of the other lamp. Compensation may be considered satisfactory for most purposes if the amount of this readjustment in voltage is not greater than 10 percent of the original colour match voltage of the lamp.

5.3.2 Compensation by the addition of coloured media to the material of the integrator coating is specifically not recommended. The colour match which may be so obtained is not usually accompanied by a sufficiently close energy match in the spectral qualities of the light from the source and that which emerges from the integrator. This may result in significant errors in certain cases, for instance, in the comparison of sodium or mercury vapour discharge lamps with tungsten filament standard lamps.

5.4 Screens — A screen should be provided, the positon of which can be adjusted to prevent the window used for the photometric measurement from receiving any direct light from the luminous source. The screen should be coated with the same material as that used for the internal surface of the integrator. It should be placed between the luminous source and the window at a distance from the luminous source of not less than one-third, nor more than one-half of the distance between the luminous source and the window. The size of the screen should be as small as possible consistent with the condition that no direct light from the source reaches the window used for the photometric measurement.

5.5 Position of Lamp Under Test

5.5.1 The lamp under test and the working standard lamp should be placed either in the same position or symmetrically with respect to the window of the integrator, or the screened area of the integrator wall on which observations are made.

5.5.2 For fluorescent lamps the preferred position for test is with the lamp mounted centrally in the integrator and operated in the horizontal position.

5.5.3 Any light source having marked directional light characteristics shall be mounted so that the peak intensity is not projected towards the screen, but towards a part of the integrator clearly visible from, but not near to, the window.

5.6 Internal Fittings — All internal fittings, such as lampholders, should be preferably painted with the same paint as is used for the internal surface of the sphere or whitened to have at least as high a reflection factor as the surface of the integrator and should be so small and so positioned that they receive either no direct light, or a minimum of direct light from the source.

APPENDIX A

(*Clauses* 0.2 *and* 5.2.1)

INTERNAL SURFACE COATING

A-0. GENERAL

A-0.1 Integrating spheres may be constructed of various materials, including copper, steel, zinc, aluminium, plywood or plaster. Whatever the material used it should be suitably prepared and primed so as to give a smooth surface suitable to receive coating compositions of the type recommended in this appendix.

A-1. PRETREATMENT AND PRIMING

A-1.1 Pretreatment and priming will not in general affect the optical properties of the finished system, but should be such as to ensure good adhesion to the base material and freedom from subsequent corrosion, flaking, etc.

A-2. INTERNAL SURFACE COATING

A-2.1 The internal surface coating recommended consists of the following:

a) a white base coat ; and

b) a water-removable white matt coat, which when soiled can be removed and fresh layers applied.

A-2.1.1 In general it will be necessary to renew only the water-removable coat, but in cases where the base coat has become discoloured, it may be necessary to remove this completely by rubbing or scraping and to apply a new base coat. In cases where breakdown of the underlying layers has occurred, it may be necessary to remove both the base coat and priming down to the metal or wood and then to proceed as for new work.

A-3. WHITE BASE COAT

A-3.1 It is desirable that the base coat should give a white matt surface and should show no yellowing with age. The composition used to produce the coat should, therefore, contain an adequate proportion of a good white pigment of high hiding power (for example, titanium dioxide) dispersed in a binding medium known to be substantially non-yellowing.

A-3.1.1 Two full coats of white composition of the polyvinyl acetate emulsion type, can be recommended as giving a suitable base coat.

A-4. WATER-REMOVABLE WHITE MATT COAT

A-4.1 The properties required in this coating may be achieved by a composition based on a good white grade of fine precipitated barium sulphate

(blanc fixe) dispersed in a water-soluble, substantially non-yellowing medium, such as a fine grade of sodium carboxymethyl cellulose as free from fibres as possible. Other colloids with similar properties are also available.

A-4.1.1 The white composition may be tinted to the required reflection factor by addition of a small quantity of a well-dispersed aqueous paste of a carbon-black pigment with a bluish undertone, that is, of a grade commercially known as ivory, drop, vegetable or lamp-black.

NOTE — Artists' water-colour ivory black is one example of a suitable ready-prepared paste.

A-4.2 To produce a composition which will give the necessary smooth matt coat requires some care not only in the selection of material but also in compounding them. One methed is described in **A-4.2.1** (wherein details of recommended quantities are also given) and **A-4.2.2.**

A-4.2.1 *Quantities*

1 000 parts by weight blanc fixe
25 parts by weight sodium carboxymethyl cellulose (SCMC)
1 000 parts by weight distilled water

A-4.2.2 *Preparation* — The blanc fixe is dispersed in distilled water, assisted by a dispersing agent (for example 0·2 percent by weight of the pigment of sodium hexametaphosphate), using a mixer or ball mill such as is used in paint making. It is then tinted to the required reflection factor.

A-4.2.2.1 It is important to ensure that a uniform smooth paste is obtained.

A-4.2.2.2 The amount of water used at this stage should be kept as small as possible and should only be just sufficient to give a paste of consistency suitable for the particular conditions of mixing or milling used.

A-4.2.2.3 The colloid is dissolved in sufficient distilled water to give a 5 percent solution by either:

a) leaving the mixture overnight to swell, or
b) heating the mixture to 90°C on a water-bath for about one hour, with stirring.

A-4.2.2.4 The resulting solution shall be clear and fibre free.

A-4.2.2.5 The colloid solution and the blanc fixe dispersion with a small quantity of black paste added are intimately mixed and the remaining quantity of water is then added, the mixture being stirred during the process.

A-4.2.3 *Application* — Two to four full coats of the white matt composition may be applied by brush, spray, or other means as convenient.

A-4.2.3.1 It is recommended that by spraying, uniform coating of the paint is achieved.

A-4.2.3.2 This paint has a reflection factor of 0·95 and the value is easily reducible to 0·80 when desired, simply by adding a predetermined amount of black waterproof ink (Indian ink).

A-4.2.4 The SCMC solution shall be freshly made for each of batch of paint mostly before use, and shall not have any preservative added.

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